
ITS Publications in FY 1996

NTIA Publications

D.J. Atkinson, "Exploring B-ISDN performance: selected experiments and results," NTIA Report 96-329, Apr. 1996.

This report describes experiments conducted to explore the user-information transfer performance of the broadband integrated services digital network (B-ISDN), the emerging infrastructure for the global information age. These performance experiments include studying the effect of physical layer transmission performance on asynchronous transfer mode (ATM) cell transfer performance, ATM performance in relationship to network topology, and the impact of B-ISDN performance on video quality. A tool to help study these performance issues, a B-ISDN network emulator, is described, including its validation. The emulator incorporates a novel model for transmission impairments, enabling performance interactions among the B-ISDN protocol layers to be studied based on relevant International Telecommunication Union-Telecommunication Standardization Sector (ITU-T) recommendations and American National Standards.

R. Dalke, G. Hufford, and R. Ketchum, "Radio propagation considerations for local multipoint distribution systems," NTIA Report 96-331, Aug. 1996.

A local multipoint distribution system will essentially broadcast television signals (and perhaps more) to subscribers in small cells. It has been proposed to put such systems in the frequency band from 27.5 to 29.5 GHz where the wave length is only about 1 cm, and where equipment is not well established and propagation effects are not entirely known. In this report we discuss what is known about the expected behavior of the radio waves and we suggest areas that need more study.

C.L. Holloway, P.L. Perini, R.R. Delyser, and K.C. Allen, "A study of the electromagnetic properties of concrete block walls for short path propagation modeling," NTIA Report 96-326, Nov. 1995.

For short propagation paths, correctly representing reflections of electromagnetic energy from

surfaces is critical for accurate signal level predictions. In this paper, the method of homogenization is used to determine the effective material properties of composite material commonly used in construction. The reflection and transmission coefficients for block walls and other types of materials calculated with these homogenized effective material properties are presented. The importance of accurately representing the reflections for signal level prediction models is also investigated. It is shown that a 5- to 10-dB error in received signal strength can occur if the composite walls are not handled appropriately. Such accurate predictions of signal propagation over short distance is applicable to microcellular personal communications services deployments in urban canyons as well as indoor wireless private branch exchanges and local area networks.

J.F. Mastrangelo and W.R. Rust, "Testing and evaluation of the subcarrier traffic information channel," NTIA Report 96-333, Sep. 1996.

In support of the Federal Highway Administration of the United States Department of Transportation, the Institute for Telecommunication Sciences has completed a laboratory and field test program designed to independently evaluate the performance of an FM subcarrier-based traveler information broadcast system. This system was developed by the MITRE Corporation to investigate the use of FM subcarriers for the broadcast of traffic data to vehicles on highways. The testing and evaluation program measured the Subcarrier Traffic Information Channel (STIC) system performance both in the laboratory and when installed in the subcarrier channel of a commercial FM broadcast station. STIC performance was measured and evaluated in a variety of reception environments in order to assist in the future prediction of STIC coverage in areas of the United States that differ dramatically in terrain and population density.

T.G. Sparkman, D.R. Wortendyke, C. Riddle, and G.P. Smith, "Testing automatic link establishment high frequency radios using compact disc technology part 1: clean tones," NTIA Report 96-327, Feb. 1996.

A method of high frequency (HF) radio interoperability testing in accordance with Federal Standards 1045A and 1046/1 is now available on a compact disc (CD) created by engineers at the National Telecommunications and Information Administration, Institute for Telecommunication Sciences. This report describes both the use of the CD and the software that created the sound files recorded on the CD. The sound files, which can be recreated by the program on a personal computer and played through a PC sound card, were recorded on a compact disc and packaged with the executable software for distribution to the public. The use of the CD for interoperability testing is explained, and tools are provided to simplify testing, such as data log sheets and additional utility software.

A.D. Spaulding, "The natural and man-made noise environment in personal communications services bands," NTIA Report 96-330, May 1996.

This report presents a summary of the available measurement information on the level and statistical characteristics of the background noise environment in the frequency range of 1-3 GHz. The frequency range covers the proposed frequencies for the new personal communications services. Natural and man-made unintentional radiations are covered, both the general overall background noise and noise from individual sources. The urban noise environment in this frequency range is due primarily to automotive ignition systems. The noise is non-Gaussian in character, but not highly impulsive.

J.A. Wepman and J.R. Hoffman, "RF and IF digitization in radio receivers: theory, concepts, and examples," NTIA Report 96-328, Mar. 1996.

Hardware development of analog-to-digital converters (ADC's) and digital signal processors, including specialized integrated circuits, has advanced rapidly within the last few years. These advances have paved the way for development of radio receivers using digitization at

the IF and in some cases at the RF. Applications for these receivers are expected to increase rapidly in areas such as cellular mobile, satellite, and personal communications services (PCS) systems. The constraints placed on these receivers due to hardware limitations of these devices are investigated in this paper. Some examples of state-of-the-art ADC's, signal processors, and specialized integrated circuits are listed. Various quantization techniques, non-linear compression devices, postdigitization algorithms for improving dynamic range, sampling downconverters, and specialized integrated circuits are discussed as they are expected to be useful in the development of these types of receivers. Several examples of radio receivers employing digitization at the IF and RF are also presented.

Other Publications

S.A. Cohn, J.K. Smith, C. Martin, and C.L. Holloway, "Spaced antenna profiler wind measurement: implementation," in *Proc. 27th Internat. Conf. Radar Meteorology*, Vail, Colorado, 1995, pp. 326-328.

To infer winds, spaced antenna radars calculate the motion and evolution of the diffraction pattern associated with atmospheric scatterers in the radar resolution volume. Doviak et al. (1994) provide a theory for the cross-correlations and cross-spectra of signals from spaced radar antennas and suggest several analysis techniques by which the horizontal wind can be determined. These techniques were developed to allow for temporal decorrelation of the scattering medium diffraction pattern. The wind component is found along baselines formed by pairs of antennas, and the theory related the spatial spectrum of the atmospheric refractive index field to the cross-correlation in time-domain analysis and cross-spectrum in frequency domain analysis. A description of these algorithms is provided in Holloway et al. (1995, this volume) and we will refer to equations therein with the prefix "H." Cohn and Chilson (1995) discuss potential advantages of spaced antenna wind profilers in the boundary layer. This paper describes implementation of these techniques and some preliminary results.

R. Dalke, G. Hufford, R. Ketchum, and K. Hugenberg, "Analysis of multipath and channel equalization for multichannel multipoint and local multipoint distribution services," in *Proc. 8th Internat. Conf. Wireless Communications*, vol. 2, Calgary, Alberta, 1996, pp. 333-346.

The Institute for Telecommunication Sciences (ITS) has developed computer simulation models which can be used to predict coverage and quality of service for proposed terrestrial communications systems that broadcast digital television such as Local Multipoint Distribution Systems (LMDS) and Multichannel Multipoint Distribution Systems (MMDS). An important consideration in the analysis of MMDS and LMDS is the efficacy of channel equalization of broadband signals subject to various multipath environments. To simulate multipath environments encountered by these systems, we have developed and implemented a statistical multipath propagation channel model which is based on measurements of the impulse response of broadcasts from operating television stations in a variety of environments (urban, suburban, and rural). The propagation channel model is a Gaussian process with the assumption that as a random process it is describable with only two parameters. A description of this model and results of simulations are presented in this paper.

R. Dalke, G. Hufford, R. Ketchum, and K. Hugenberg, "Digital simulation of radio propagation effects for terrestrial digital television broadcast services," in *Proc. 1996 Wireless Communications Conf.*, Boulder, Colorado, 1996, pp. 98-101.

Recently there has been considerable interest in the terrestrial broadcast of digital television using Multichannel Multipoint Distribution Services (MMDS) and Local Multipoint Distribution Services (LMDS). These services operate in the SHF and EHF bands and are subject to deleterious radio propagation effects such as attenuation and multipath. In addition, radio system effects (e.g., nonlinear amplifier characteristics) should also be considered for broadband millimeter wave systems. In response to this need, the Institute for Telecommunication Sciences (ITS) has developed computer simulation models which can be used to predict coverage and quality of service for such broadcast services [1]. Here we will give a brief descrip-

tion of the model and examples of simulation results.

N. DeMinco and J.A. Arnold, "What is an EMC program and why is it important to ITS" in *Proc. ITS America Sixth Annual Meet.*, vol. 2, Houston, Texas, 1996, pp. 1058-1065.

This paper discusses the role of electromagnetic compatibility (EMC) in Intelligent Transportation Systems (ITS). It is important that an EMC program be implemented early in ITS development to ensure compatibility of ITS equipment and subsystems with each other and their environment. The use of current standards would greatly reduce the cost and time needed to implement an EMC program plan for ITS. If such a program is not implemented, compatibility problems could arise and cause performance degradation or malfunction of the subsystems of ITS. This paper describes EMC as it relates to ITS and how an EMC program plan would be implemented. The application of existing standards to ITS is also discussed.

R. J. Doviak, R.J. Lataitis, and C.L. Holloway, "Cross-correlation and cross-spectra in spaced antenna wind profilers part 1: theoretical analysis," *Radio Science*, vol. 31, no. 1, pp. 157-180, 1996.

The presented theory ties the properties of a turbulently advected scattering medium to the cross correlation and cross spectrum of signals in a general configuration of receiving and transmitting antennas. The correlation length of Bragg scatterers and antenna diameter are the significant parameters determining the diffraction pattern's correlation length. We examine how vertical anisotropy of the scattering medium affects the diffraction pattern's correlation length. We demonstrate that the cross spectrum can be formulated in terms of a pair of spectral sampling functions (a one-dimensional Doppler and a three-dimensional wavenumber function), and closed form solutions are obtained. We give the conditions under which the scattering medium's statistical properties can be represented by a Gaussian correlation or spectral model, and the distance over which the diffraction pattern simply advects without significant change. We show that the diffraction pattern of a pair of scatterers can translate at the speed of the scatterers, not twice their speed as is commonly thought.

J.G. Ferranto, "PCS 1900 interference simulation for personal communications services testing, evaluation, and modeling," in *Proc. 5th IEEE Internat. Conf. Universal Personal Communications*, vol. 1, Cambridge, Massachusetts, 1996, pp. 225-230.

A generic methodology for personal communications services self-interference modeling is applied to the Global System for Mobile-based PCS 1900. The resulting system-specific model is discussed in detail, and is used to produce output noise and interference waveforms suitable for implementation in a real-time hardware channel simulator, or as a component of a link-level software simulation. Different deployment scenarios are then used to generate example PCS 1900 interference waveforms, along with corresponding statistical analyses of interference waveform properties. The model described in this paper is particularly well-suited for support of efficient PCS system evaluation.

E.M. Gray and D. Bodson, "Preserving due process in standards work," *StandardView*, vol. 3, no. 4, pp. 130-139, Dec. 1995.

Due process refers to a legal concept and to the practice based on that concept. This paper begins with a brief review of the relevant legal and historical concepts, then more fully addresses the ways of preserving due process in the work of developing information-technology standards. The necessary and minimum procedures for preserving due process in standards working groups are identified. Connections are made between a) the defined elements of due process and b) the ways in which ANSI's X3 and other standards working groups preserve due process in their work. With regard to accelerated procedures for standards development, the paper addresses briefly the need to balance timely standards development with due process. The paper identifies the advantages—to the standards user—of preserving due process in standards development.

J.A. Hoffmeyer and D. Bodson, "Present status and future development of U.S. Federal standards for HF communications," in *Proc. IEE Colloquium on Frequency Selection and Management Techniques for HF Communications*, Savoy Place, London, 1996, pp. 19/1-19/5.

High frequency (HF) communications systems continue to be an important component of the

suite of systems needed to meet both military and civil communications requirements. These military and civil applications of HF require the establishment of national and international interoperability and performance standards.

The United States has established a program for the development of a series of Federal HF Standards which are applicable to all United States Government departments and agencies. The National Communications System (NCS) is responsible for the development of Federal communications standards as part of its mission. The NCS responsibilities for National Security and Emergency Preparedness (NS/EP) functions for telecommunications systems include the responsibility for ensuring interoperability of a wide variety of telecommunications systems. The Institute for Telecommunication Sciences (ITS) is working jointly with the NCS in leading the development of Federal Standards that specify HF systems performance and interoperability requirements.

This paper summarized the status of existing U.S. HF Federal Standards, the current and future work in the development of additional U.S. Federal Standards, and identifies issues as to how these United States Federal HF standards relate to international standards activities within NATO and the International Telecommunication Union-Radiocommunication Sector.

J.A. Hoffmeyer and D. Bodson, "Use of advanced HF link and network simulators in the standards development process," in *Proc. IEE Colloquium on Frequency Selection and Management Techniques for HF Communications*, Savoy Place, London, 1996, pp. 12/1-12/7.

Modeling and simulation are important components of present day HF radio communications standards development process. This paper summarized work at the Institute for Telecommunication Sciences (ITS) under the direction and funding of the National Communications System (NCS) in the development of simulation tools useful in the HF standards development process in the United States. The simulation tools are introduced from the perspective of 1) the phase of the standards development process to which the tools may be applied and 2) the communication system layer to which they may be applicable. Particular emphasis in

this paper is placed on the development of a new real-time HF channel simulator, the development of a compact disk-based automatic link establishment (ALE) tone simulator, and the development of a general purpose digital signal processor-based system for simulating HF network protocols.

C.L. Holloway, R.J. Doviak, S.A. Cohn, and R.J. Lataitis, "Retrieval of boundary layer turbulence using spaced antenna wind profilers," in *Proc. 1996 Internat. Geoscience and Remote Sensing Symp.*, 1996, pp. 1914-1916.

In this paper, we present an algorithm for estimating turbulence (or wind variability) in the lower boundary layer for use with spaced-antenna systems.

C.L. Holloway, R.J. Doviak, S.A. Cohn, R.J. Lataitis, and J. Van Baelen, "Algorithms to retrieve wind from spaced-antenna wind profilers," in *Proc. 27th Internat. Conf. Radar Meteorology*, Vail, Colorado, 1995, pp. 323-325.

In this paper, four algorithms for determining unbiased estimates of the wind from a spaced-antenna wind profiler are introduced.

C.L. Holloway and E.F. Kuester, "A quasi-closed form expression for the conductor loss of CPW lines, with an investigation of edge shape effects," *IEEE Trans. Microwave Theory and Techniques*, vol. 43, no. 12, pp. 2695-2701, Dec. 1995.

In previous work, we used a matched asymptotic technique to investigate the fields near an edge of a finitely conducting strip with nonzero thickness. It was demonstrated that with this asymptotic solution of the fields, the power loss in the region local to the edge could be determined accurately. In this paper, we will show how the accurate representation of the power loss can be used to obtain a closed form expression for the attenuation constant due to conductor loss of coplanar waveguide (CPW) structures. This expression is valid for an arbitrarily shaped edge and any conductor thickness. Results obtained with this expression are compared to and closely agree with both experimental results and other techniques found in the literature. We also investigated conductors with different edge shapes (45 degree and 90 degree edges) to explore their effect on the attenuation constant (or loss) of CPW structures.

C.L. Holloway and E.F. Kuester, "Modeling semi-anechoic electromagnetic measurement chambers," *IEEE Trans. Electromagnetic Compatibility*, vol. 38, no. 1, pp. 79-84, Feb. 1996.

In previous work, we have developed a model to predict theoretically the low-frequency plane-wave reflection coefficient of an array of pyramid cone absorbers such as those used to line anechoic electromagnetic measurement chambers. In this paper, we apply this model in a geometrical optics approach to predict the electromagnetic field in a chamber lined with cone absorbers in the frequency range of 30-300 MHz. The results are compared with site attenuation measurements for two actual semi-anechoic chambers.

P. Papazian and G. Hufford, "Initial study of the local multipoint distribution service radio channel," in *Proc. Wireless 1996 8th Internat. Conf.*, vol. 2, Calgary, Alberta, 1996, pp. 494-513.

A broadband millimeter wave study was completed to characterize the radio channel for local multipoint distribution services (LMDS) in Boulder, Colorado. The study determined characteristics for proposed 20-MHz channels centered at 30.3 GHz using two transmitter heights in a suburban environment in the winter. Distributions of signal loss, delay spread and frequency selective fading are presented. The median excess path loss for a 40-m transmitter height is 15 dB. Maximum delay spreads for this height are below 10 ns with a median value of less than 1 ns. Data was also collected to characterize a flat plate reflector proposed for use at 28.8 GHz. The measurement results indicate that vegetation causes significant propagation impairments for LMDS.

E.A. Quincy, R.J. Achatz, and M. Terada, "IS54/I36 PCS performance prediction for standard JTC channels," in *Proc. Wireless 1996 8th Internat. Conf.*, vol. 1, Calgary, Alberta, 1996, pp. 43-57.

Several Joint Technical Committee (JTC) Air Interface Standards have been proposed for PCS. Standardized operational channel models were also developed by the JTC to provide a common operational environment in which to compare performance of these radio systems. We have investigated the performance of an IS54/I36-based PCS system operating over a range of signal-to-noise ratios (SNRs) using

three of the urban channel models. Performance is given in terms of bit error rates (BER), compressed speech quality, and compressed image quality.

E.A. Quincy, R.A. Dalke, R.J. Achatz, C.L. Holloway, and P.M. McKenna, "Radar target image resolution enhancement via propagation channel equalization," in *Proc. SPIE Radar Processing, Technology, and Applications*, vol. 2845, Denver, Colorado, 1996, pp. 49-55.

The performance of signal/image processing algorithms used to form radar images and identify targets depends on propagation effects such as time-varying multipath, dispersion, attenuation, etc. In this paper, the effects of multipath propagation conditions that result from terrain or man-made environments and noise are modeled and simulated to determine their effects on radar target signatures. Here, we calculate the radar signatures for a ground vehicle subject to the deleterious effects of both multipath and additive noise. A minimum mean-square-error (MMSE) Wiener equalizing filter is developed and applied to the distorted radar target signatures. The mean-square-error (MSE) is calculated as a function of signal-to-noise ratio resolution. These techniques are particularly relevant for targets located in mountain or urban canyon environments.

Spaulding, A.D., 1995, "The roadway natural and man-made noise environment," *IVHS Journal*, vol. 2, no. 2, pp. 175-211.

This paper presents a summary of the available measurement information on the level and sta-

tistical characteristics of the background natural and man-made noise likely in highway and other high traffic density locations. The frequency ranges of around 100 MHz and 0.9 to 3 GHz are covered since these frequency ranges are those of current interest for "intelligent highway" telecommunication systems. The highway noise environment in these frequency ranges is due primarily to automotive ignition systems (and power lines at 100 MHz). The noise is non-Gaussian in character.

S. Voran, "Observations on auditory excitation and masking patterns," in *Proc. 1995 IEEE ASSP Workshop on Applications of Signal Processing to Audio and Acoustics*, New Paltz, New York, 1995.

Excitation patterns and masking patterns are used extensively in perceptual audio coders and quality assessment algorithms. Numerous algorithms for calculating these patterns have been proposed. This paper provides comparisons among the patterns generated by several of these algorithms. The comparisons are based on audio program material, rather than tones and noise. Explored areas include synthesis functions, spreading functions, masking indices, tonality measures, and the treatment of the absolute threshold of hearing. Several mathematical relations are provided to characterize observations in these areas. Patterns from simpler algorithms are considered as approximations to patterns from more complex algorithms, and the approximation error is characterized. Results may be useful to those who apply auditory excitation or masking patterns in their work.

Publications Cited*

CCIR, "HF ionospheric channel simulators," Report 549-3, International Telecommunication Union, Reports of the CCIR, 1990, Annex to Volume III, Fixed Service at Frequencies Below About 30 MHz., Geneva, 1990, pp. 47-59.

R.O. DeBolt, et al., "A technical report to the Secretary of Transportation on a national approach to augmented GPS services," NTIA Special Publication 94-30, 1995.

E.J. Violette, R.H. Epseland, and K.C. Allen, "A diagnostic probe to investigate propagation at millimeter-wave lengths," 1983, NTIA Report 83-128, August 1983 (NTIS Order No. PB-104223).

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